XIII. *Experiments in* 1890 *and* 1891 *on the colour-relation between certain lepidopterous larvæ and their surroundings, together with some other observations on lepidopterous larvæ.* By Lilian J. Gould. Communicated by Edward B. Poulton, M.A., F.R.S., &c.

[Read October 5th, 1892.]

Plate XI.

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In the summer of 1890 I undertook to make some observations on the colour-relation between certain lepidopterous larvæ and their surroundings, at the suggestion of my friend Mr. E. B. Poulton, of Oxford. The experiments, of which the following is an account taken from notes made day by day at the time, were conducted under the kind direction of Mr. Poulton, to whom I was constantly indebted for help and advice, and may be of interest chiefly as confirming results already obtained by him (with larvæ of *R. cratægata* and others), and partly also as bringing forward evidence affecting colour-relation in species of which no results had been published hitherto (*M. brassicæ*).

The experiments extended over 1890 and 1891, and are here presented in diary form, together with drawings of the larvæ made at the time. In addition to the summary of results given at the end of each experiment, a total summary of results will be found at the conclusion of the whole series of experiments on colour-relation.

During the whole period of experiment all the larvæ were kept in numbered glass cylinders, supported on plates over vessels of water, like those used by Mr. Poulton in previous experiments. A hole through the plate allowed the stems of the food-plant to reach the water, and thus it was kept fresh. The tops of all cylinders were covered with fine white muslin, held in place by elastic bands; and to prevent the escape of larvæ, when very small, between the cylinder and the plate, the junction was surrounded by very fine sand.

Section I.

Notes on larvæ of Rumia cratægata.

On June 23rd, 1890, I received, from Mr. Poulton, fertile ova of *R. cratægata*, from one parent, for purposes of experiment.

June 24th.—22 larvæ hatched. These were all placed in one cylinder, and fed on hawthorn, the sprigs of the food-plant not being chosen at this time with any regard to colour. The larvæ were examined several times daily, and days on which no alteration in their condition was observable were noted as "no change"; these are omitted in the present account.

July 1st.—The first ecdysis occurred; all the larvæ having hatched out on the same day, moulted at the same time, with only a difference of hours.

July 7th.—I divided the larvæ into two sets, placing 11 in cylinder 9, and 11 in cylinder 5. The following observations refer to those in cylinder 9, which were supplied from this time with green leaves only, very young shoots of hawthorn being selected for this purpose. My intention was to exclude every colour but green from their surroundings, but this was rather difficult, as the stalks of the leaves of hawthorn were too short to admit of their being gathered and kept fresh in water separated from the twig, and the stems were always liable to be brown or brownish in colour. This difficulty was obviated as far as possible by selecting only the very youngest shoots of hawthorn, in which the leaves were very bright green, and one side of the stem was always bright green, the other side of the stem and the thorns being of a crimson colour.

July 9th.—The second ecdysis occurred. From this

time the larvæ began to show signs of change of colour, and became greenish in hue, the original colour having been varying shades of brownish grey or dusky brownish green.

July 18th.—Length of largest larva, 14 mm. Two larvæ disappeared, probably having escaped through some crevice, or been lost in changing the food.

July 19th. — The third ecdysis took place. The nine larvæ left showed a distinct change of colour to green.

July 22nd.—All 9 larvæ were of shades of green or greenish brown. They varied a good deal in shade; three were very bright green, exactly matching the leaves of the food-plant, and had the dorsal tubercles, the head, and the thoracic legs of a crimson-red, perfectly corresponding to the colour of one side of the hawthorn-shoots and of the thorns. The other six were of a green, more or less bright, and all were touched with red on the parts above mentioned. None were brown, or even brownish green.

July 26th.—The fourth ecdysis occurred.

July 27th.—I drew the brightest green larva, namely, that figured in Pl. XI., fig. 1.

July 31st. — One of the larvæ left off feeding, and mounted to the roof of the cylinder.

Aug. 2nd.—A second larva did the same; and by Aug. 22nd all the larvæ had pupated, spinning pinkish-white cocoons in close proximity to each other on the roof of the cylinder.

The total results of the experiment with these 9 larvæ were as stated below: —

Colour.	No. of larvæ.
Brilliant green	1
Lighter green, but very bright	2
Duller shades of green	6
Brown and other colours	0
Total	9

Of the 22 larvæ divided on July 7th, 11 were placed in cylinder 5, and reared among *dark* surroundings. They were supplied, from the time of separation, with hawthorn from the same tree as that used for the larvæ with green surroundings. But in this case older twigs were

chosen, which had very dark green leaves and brown woody stems; and further, with the sprigs of the food-plant were mixed a number of small dark-coloured sticks. It was desirable to have these sticks as dark as possible, and, as natural twigs were not easily procurable dark enough in colour, I used dry stems of furze, taken from places on a neighbouring moor where the gorse had been burned in patches; in these places the stems and twigs alone remained, and of course were perfectly dead-black. When the superficial powdery charcoal had been wiped off with a cloth, the larvæ crawled as readily upon these sticks as upon living twigs, and generally rested upon them in preference to the leaves or stems of the food-plant. The following notes refer to these larvæ in No 5:—

July 8th.—The second ecdysis took place, and the larvæ began to darken in colour perceptibly, varying from the usual dusky hue to shades of brown, and brownish slightly mottled with green; two were green, but very dark.

July 16th.—The third ecdysis occurred. The larvæ continued to darken, one having become very dark indeed, so that it was almost the colour of the sticks.

July 20th.—One larva died; thus 10 were left.

July 24th.—The fourth ecdysis occurred.

July 26th.—I drew the darkest specimen, figured in Pl. XI., fig. 2. The length of the smallest larva at this time was 16 mm.

July 29th. — The first larva pupated, spinning a whitey-brown cocoon on the upper surface of a leaf.

Aug. 3rd.—Two more pupated between the sticks. Unfortunately I omitted to record the exact shade of colour of these three, but they were certainly all brownish.

Of the 7 larvæ left, 3 were very dark brown, so nearly approaching to black as to be quite indistinguishable, except by the closest search, from the sticks on which they rested; two were brown, with a slight tinge of green; and two were distinctly green, though less bright green than the dullest green larva in No. 9.

Aug. 9th. — 3 more larvæ pupated; one dark brown one and one green one were left.

Aug. 13th.—The green larva pupated between leaves.

Aug. 16th.—The last larva pupated.

Total results of the foregoing experiments :—

Colour.	No. of larvæ.
Dark brown approaching to black ...	... 3
Brownish, shade unrecorded	... 3
Brown, with green tinge	... 2
Green	... 2
Other colours	... 0
Total ...	... 10

The change of colour in both sets of larvæ became perceptible at the commencement of the third stage of larval life (after the second ecdysis), and the resemblance to surroundings seemed to increase very gradually in perfection up to the fourth ecdysis, after which the colour underwent no further change, except the usual and easily distinguishable darkening or alteration preceding pupation.

My experiments with this species fully confirmed those previously carried out by Mr. Poulton, and mentioned by him in the 'Report of the British Association,' 1887, p. 756, and in 'Nature,' vol. 36, p. 594, now being published in full. The larvæ attained a really wonderful degree of resemblance to their surroundings ; in the case of my larvæ with green surroundings this likeness was greatly heightened by the touches of red, which exactly matched the thorns and one side of the stem of the young hawthorn shoot.

The resemblance in shape, as well as colour, is extremely protective, the angular attitude of the larva at rest rendering it almost indistinguishable from the twig; a fact also mentioned by Mr. Poulton (Trans. Ent. Soc. Lond., 1887, p. 291).

2. *Notes on larvæ of* Catocala nupta.

In May, 1890, I procured, from Mr. E. Edmonds, of 31, Park Street, Windsor, 48 fertile ova of the Red Underwing Moth (*Catocala nupta*), with a view to making experiments in colour-change, the species being recommended to me for trial by Mr. Poulton.

From May 27th to June 25th, 46 larvæ hatched out, and two of these died ; so that 44 remained for experimental purposes. These I divided into three sets, giving to the first set black sticks with the food-plant ; to the second set green leaves only ; to the third green leaves and *white* sticks, carefully peeled to remove the coloured

bark, and changed for freshly prepared ones whenever they became yellowish or discoloured by drying.

At first all three sets were fed on willow (*Salix vitellina*) from the same tree, but after a time, having discovered a kind of willow with whitish silvery leaves (*S. regalis*), I fed the third set (those with white sticks) with the white willow also, in order to see if any difference of shade would be produced between these and the larvæ on green willow without sticks. The larvæ of *C. nupta* being rather large, it was necessary to have a great number of cylinders, to avoid overcrowding. The larvæ with dark surroundings were placed in cylinders 7 and 12, the larvæ with green surroundings in cylinders 3, 8, and 10, and those with white surroundings in cylinders 11 and 16.

As the hatching-out had extended over a period of nearly four weeks, it was necessary to divide the larvæ as nearly as possible according to age, so as to render observations as to times of ecdysis, &c., easier and less liable to error. The experiments with *C. nupta* were not as satisfactory as those made with other species, as the larvæ were never so healthy, and very many died when nearly full-fed, from some cause which I could not discover.

The following notes refer to larvæ with dark surroundings :—

Cylinder 7. — June 17th. — Six larvæ hatched, and were placed in cylinder 7. The newly-hatched larvæ measured not quite 6 mm., and their colour was uniform dark brown. They were fed on *Salix vitellina*, the darkest green leaves being selected, and given on the twig.

June 20th.—The first ecdysis occurred, with no change of colour.

June 30th. — I gave black sticks of the same kind as those used for *R. cratægata* in previous experiments. Later in the day the second ecdysis took place.

July 1st.—The larvæ began to darken perceptibly, and the adjustment of colour gradually increased in perfection during this and the succeeding stage.

July 9th. — The third ecdysis occurred. The larvæ were all distinctly brown, and darker than any of those with other surroundings.

July 18th.—The fourth ecdysis took place.

July 19th. — I drew one of the largest larvæ. This larva (figured in Pl. XI., fig. 4) was the darkest I obtained, and measured 7½ cm. in length. By this time all the six larvæ were very dark, that is, darker than the darkest of those with green or white surroundings. The whole ground colour of the body was a clear brown, not brownish merely or brownish grey; the two wavy dorsal lines were broadly and distinctly marked in very dark brown in one larva, and less darkly but distinctly in the other five. The head and dorsal humps were tawny, outlined and marked with black.

From the time of the last ecdysis, the larvæ had been showing signs of unhealthiness, and now they died off one by one. By Aug. 3rd only one was left—the darkest—and this larva died on Aug. 6th. I was not able to discover the cause of death, and up to this time they had fed as usual, and seemed to thrive well.

Total results of the foregoing experiment :—

Colour.	No. of larvæ.
Dark brown (dorsal lines very dark)	1
Brown (dorsal lines distinct, but not so dark) ...	5
Total	6

Cylinder 12.—June 25th.—I put six larvæ (hatched on one day) in the second stage into cylinder 12, and gave black sticks with the food-plant (*Salix vitellina*). Up to this time they had had leaves without sticks or attention to the colour of the leaves.

July 4th —The second ecdysis took place.

July 7th.—With this set I was using the plan adopted by Mr. Poulton in some of his earlier experiments, *viz.*, that of surrounding the cylinder with tissue-paper of the shade required, with a view to deepening the effect. On this day I applied brown tissue-paper to the cylinder containing the larvæ, and placed it in a strong light, as otherwise the paper made the cylinder almost dark.

July 9th.—Acting on advice from Mr. Poulton, under whose kind direction I was working, I removed the tissue-paper, as he had come to the conclusion that the shadow caused by it rather hindered than increased the effect of the surroundings. At this time the length of the largest larva, fully stretched, was 6½ cm., and that of the smallest nearly 5 cm. A darkening of colour had

begun to be apparent in three of the larvæ; the other three were not as yet affected by the colour of the sticks, although these three rested on them as constantly as did the darker larvæ.

July 12th.—Two larvæ died. The larvæ had seemed healthy up to this time, but now began to die off, just as those in cylinder 7 did. One of the two which died was light-coloured, the other dark.

July 13th.—The four larvæ left moulted for the third time.

July 22nd.—A third larvæ died, and another was looking very sickly. The dead larva was a light one.

July 23rd. — The fourth ecdysis occurred. Of the three remaining larvæ, one was very dark brown, and two much lighter.

July 29th.—The dark larva died, and the last two larvæ pupated between leaves. All these six larvæ were darker than any with green or white surroundings, but the general ground colour was not so dark as the darkest in cylinder 7, though the dorsal lines in the dark individuals were nearly as dark as those of the darkest specimen in 7. None of these larvæ were figured. The head and dorsal humps were as those in 7.

Total results of the foregoing experiment:—

Colour.	No. of larvæ.
Darkish brown (dorsal lines dark)	1
Lighter brown (dorsal lines dark)	2
Very light brown (dorsal lines very faint) ...	3
Total	6

The larvæ with green surroundings.

Cylinder 3.—June 27th.—I placed six larvæ in the second stage in cylinder 3. The second ecdysis occurred the same day. The larvæ up to now had been uniform dusky brown. Two began to become lighter in colour.

June 30th.—Three larvæ were of a light clear brown; markings light. Three were rather darker. Heads and dorsal humps as before.

July 4th. — The third ecdysis took place. One larva very light indeed, two nearly as light, two dark brown with dorsal lines indistinct, one dark brown, with dark distinct dorsal lines.

July 13th.—The fourth ecdysis occurred.

July 20th. — I drew the lightest larva (figured at Pl. XI., fig. 5), which was of a very light delicate shade of brown, and had scarcely a trace of the dorsal lines. The length of the largest larva at this time was $6\frac{1}{2}$ cm., of the smallest $5\frac{1}{2}$ cm.

July 23rd.—One larva died—a dark one, with dark dorsal lines.

July 30th.—The lightest larva was spinning up on the roof.

July 31st.—Another larva was spinning up on the roof.

Aug. 3rd.—Two more larvæ left off feeding. Of these four larvæ, three were very light in colour, with the dorsal lines very faint; one was dark, with distinct dark dorsal lines. One dark one left.

By Aug. 11th all had pupated, and the last larva did so on the floor without forming any cocoon. The food of all was *S. vitellina*.

Total results of the foregoing experiment:—

Colour.	No. of larvæ.
Very light brown, with very faint dorsal lines ...	1
Light brown, with faint dorsal lines	2
Dark brown, with dark dorsal lines	2
Dark brown, with indistinct dorsal lines	1
Total	6

Cylinder 8.—June 25th.—I placed six larvæ in the first stage in cylinder 8.

June 26th.—The first ecdysis took place.

June 29th. — The larvæ (until now uniform dusky brown) began to show signs of lightening in colour; one quite light.

July 2nd.—The second ecdysis occurred.

July 4th.—I was using tissue-paper for this set also, and on this day applied green tissue-paper, doubled, round the cylinder and over the roof, and placed the cylinder in a strong light.

July 8th.—The third ecdysis occurred. Two larvæ were light, three darker brown, one lightish brown.

July 9th.—I removed the tissue-paper on Mr. Poulton's advice. The length of the largest larva at this time, when fully stretched, was 5 cm., that of the smallest, 4 cm.

July 15th.—The fourth ecdysis took place. Two larvæ were quite light, four fairly dark brown.

July 27th.—One larva was spinning up on the roof. One died—a light one. Five larvæ were left, one light and four dark ones.

Aug. 1st.—Another larva was spinning up on the roof.

Aug. 3rd.—The first larva pupated. Another larva died; this was a dark one.

Aug 6th.—The last two larvæ died; both dark ones.

Aug. 7th.—The second larva pupated.

Total result of the foregoing experiment :—

Colour.	No. of larvæ.
Clear light brown, light dorsal lines ...	... 2
Darker brown, dark dorsal lines ...	... 1
Dark brown, dark dorsal lines ...	... 3
Total ...	... 6

The lightest of these larvæ were nearly, but not quite, as light as the extreme one in cylinder 3, and the darkest about matched the darkly marked two in cylinder 3. None were so dark as the dark larva figured (from cylinder 7) with *dark* surroundings. The change of colour was perceptible a stage earlier than any others. The food was *Salix vitellina*.

Cylinder 10.—June 27th.—I placed six larvæ in the second stage in cylinder 10.

July 4th.—The second ecdysis occurred. The colour until now had been uniform dusky brown, like the others. From this time the larvæ began to get lighter.

July 8th.—For this set also I was intending to use tissue-paper, and on this day applied green, doubled tissue-paper round the cylinder and over the roof, on which larvæ were resting, and placed the cylinder in a strong light.

July 9th.—I removed the tissue-paper on Mr. Poulton's advice. The length of the largest larvæ, fully stretched, at this time was 6 cm., that of the smallest nearly 3 cm.

July 12.—The third ecdysis took place. The larvæ were all as nearly as possible of the same shade of brown, a shade intermediate between the darkest and lightest in cylinder 8. The dorsal lines in all were distinct, but none very dark.

July 19th.—The fourth ecdysis occurred. The length of the largest larva, fully stretched, was 7 cm., that of

the smallest 4½ cm. The large larva measured was the largest I ever obtained of this species.

July 23rd.—The first larva left off feeding.

Aug 3rd.—One larva died.

By Aug. 12th all the larvæ had pupated.

Total results of the foregoing experiment :—

Colour.	No. of larvæ.
Light brown, with dark dorsal lines	5
Slightly darker brown, dark dorsal lines ...	1
Total	6

All these were fed on *Salix vitellina*.

The larvæ with white surroundings.

Cylinder 11.—July 2nd.—I placed twelve larvæ in the second stage in cylinder 11, feeding them on *Salix vitellina*, but mixing white sticks with the food-plant.

July 9th. — I changed the food, giving the larvæ the silver-leaved *Salix regalis* instead of *S. vitellina*, with a view to increasing the effect of the white surroundings.

July 13th.—The second ecdysis took place. The larvæ till now were of a uniform dusky brown, like all the rest. After ecdysis they were all very slightly lighter.

July 20th. — The length of the largest larva, fully stretched, was 4½ cm., the length of the smallest, 2½ cm. Four were dark brown, three lighter brown, but with distinct dorsal lines, and five were quite light.

July 22nd.—The third ecdysis occurred.

July 29th.—Two larvæ died, one dark, one light. I had had more larvæ than usual in this cylinder, being short of cylinders; but, as I was afraid they died from overcrowding, I removed five of the ten left to cylinder 16, still giving them white sticks and white willow. Five larvæ remained in this cylinder.

Aug. 1st.—The fourth ecdysis took place. One larva died, one of the intermediate forms, between dark and light.

Aug. 6th.—Three larvæ died, two light ones and an intermediate.

Aug. 20th.—The last larva died, an intermediate one.

Total results of experiment (not counting the five removed) :—

Colour.	No. of larvæ.
Light brown, faint dorsal lines	3
Darker brown, distinct dorsal lines	3
Dark brown, dark dorsal lines	1
Total	7

Cylinder 16.—July 29th.—I placed five larvæ from cylinder 11 in cylinder 16, still giving white sticks and white willow.

Aug. 1st.—The fourth ecdysis occurred. Three were dark brown and two light; none were intermediate.

Aug. 6th.—Three larvæ died, two dark ones and a light one.

Aug. 13th.—A fourth larva died ; it was dark.

Aug. 18th.—The last larva, a light one, died.

Total results of experiment :—

Colour.	No. of larvæ.
Light brown, faint dorsal lines	2
Dark brown, dark dorsal lines	3
Total	5

It will be seen from the above descriptions that none of the larvæ with green surroundings attained a green colour, or even the slightest tinge of green—a change only as yet known to be possible to a few species ; the change consisted merely in their normal colour becoming lighter or darker in depth, and the markings varying in the degree of intensity. The difference between the most extreme forms from dark and light surroundings was striking, but the difference between those from green and white surroundings slight, if any ; indeed, the extreme light specimen figured came from green, not white surroundings. The intermediate forms were very variable in shade of ground colour, and also in depth of markings. It is remarkable that in the larvæ of cylinder 8 the colour-change became perceptible three days after the first ecdysis, in the second stage of larval life, instead of after the second ecdysis (the third stage) as was the case in the others of *C. nupta*.

3. *Notes on larvæ of* Catocala fraxini.

On May 21st, 1890, twenty-four fertile ova of the Clifden Nonpareil Moth (*Catocala fraxini*) were supplied to me by Mr. E. Edmonds, of 31, Park Street, Windsor. The larvæ began to hatch out almost immediately on arrival, and by May 26th seven had emerged from the eggs. These were placed together in a cylinder, like those used for other species, and were supplied at first with the common ash. This food-plant was continued for a week, but the larvæ refused to eat any of it, and four died. This was curious, as ash is supposed to be the normal food-plant, and the one from which the species takes its name. I then changed the food, giving the remaining three larvæ leaves of the common poplar, on which they fed readily. By June 4th the total number of larvæ which had emerged was sixteen, and no more were hatched. One more larva died, and one was lost in changing the food; so that the total number remaining for purposes of experiment was ten.

On June 13th, I divided the larvæ into two sets, placing five in cylinder 2 and five in cylinder 6. Those in cylinder 6 were supplied with very young shoots of poplar, in which the stems and the leaves were alike bright green, and no sticks. Those in cylinder 2 were given older twigs, in which the stem was brownish and the leaves much darker green, and perfectly black sticks (the same as those used in previous experiments) were mixed with the food-plant. The larvæ were divided as nearly as possible according to age.

The larvæ with dark surroundings.

Cylinder 2.—June 13th.—I placed five larvæ in the first stage in cylinder 2 with black sticks. The first ecdysis occurred. When first hatched the larvæ were of a uniform dusky colour; after the first ecdysis they became very light green, which darkened gradually to almost brown. (This brownish hue did not alter, except in shade, in these larvæ after the second ecdysis; and in this, as will be seen, they differed from the larvæ with green surroundings. I considered that the colour-change began, therefore, at this period, unlike *R. crataegata* and most of *C. nupta*, in which it was perceptible only after the second ecdysis.)

June 21st.—The larvæ were all brownish, and nearly alike as to depth of colour.

June 30th.—The second ecdysis occurred. The larvæ were constantly resting on the sticks, but did not approach them in colour; only their general hue was slightly darker than that of the larvæ in green surroundings, and quite different, as seen in Pl. XI., fig. 6 (*cf.* fig. 7).

July 12th.—The third ecdysis took place. The five larvæ still varied very little as to depth of colour; the brown colour took a pinkish tinge, which gradually increased.

July 28th.—The fourth ecdysis. During the stage succeeding this moult the colour became intensified, and attained its greatest perfection. This species seemed to be susceptible to a later stage than others, in which the protective resemblance to surroundings did not increase very much after the fourth stage.

July 29th.—I drew the darkest larva (Pl. XI., fig. 6). The largest larva, fully stretched, measured nearly 7 cm. There was scarcely an appreciable difference of shade in the five larvæ.

Aug. 3rd.—The larvæ were now distinctly of a darker general shade than those with green surroundings. Their general ground colour was a brownish grey, or more correctly, perhaps, a pinkish drab; the heads were tawny, marked with black; the dorsal humps were black, and the whole dorsal surface finely mottled with very small dark specks.

Aug. 10th.—The first larva was spinning up on the floor between leaves.

Aug. 16th.—The cover of the cylinder accidentally slipped off, and two larvæ escaped and could not be found.

Aug. 17th.—All the larvæ had pupated.

Total results of experiment:—

Colour.	No. of larvæ.
Brownish grey or pinkish drab ...	... 5
Other colours	... 0
Total ...	... 5

The larvæ with green surroundings.

Cylinder 16.—June 13th.—I placed five larvæ in the first stage in cylinder 6, and gave young green shoots of

poplar only only. The larvæ when hatched were of a uniform dark colour.

June 14th.—The first ecdysis occurred. The larvæ became very light green, with a row of dark spots along the back.

June 16th.—The larvæ had darkened a little, but showed no tendency to become brown.

June 26th.—The largest larva became quiescent. It had seemed quite healthy up to this time.

June 29th.—The largest larva pupated, the pupa being only a little over 1 cm. in length, but perfectly formed. I could not assign any reason for this early pupation.

July 2nd.—The second ecdysis took place. The row of spots disappeared, but the green colour was persistent. (These spots never appeared in the larvæ with dark surroundings.)

July 6th.—The larvæ were still all green, but paler.

July 14th.—The third ecdysis occurred. The shade of green of all the larvæ became very delicate and bluish.

July 20th.—Up to this time the food had been young green shoots with green stems, but now, finding it possible to procure leaves with stalks long enough to use singly, I gave leaves only for the rest of the time.

July 21st.—The fourth ecdysis took place, and was followed by a slight intensification of colour in all five larvæ.

July 22nd.—I drew the greenest larva (Pl. XI., fig. 7), but, like the larvæ in cylinder 2, these varied very slightly in depth of colour. Their general ground colour was a light and peculiarly delicate shade of bluish green; the dorsal surface was tinged with a shade of brownish grey, so light as to be barely perceptible, and was mottled with minute dark specks; the heads were tawny, pencilled with black; the dorsal humps black-marked; the legs and claspers green, of the same shade as the body. The largest larva measured nearly 7½ cm.; this was the largest larva obtained in the case of this species.

Aug. 9th.—The first larva was spinning up on the floor.

Sept. 2nd.—The second larva pupated. I saw it immediately after pupation; the pupa then was of a bright deep shade of yellowish green. It had come out from its partially-spun cocoon and pupated outside.

Sept. 3rd.—The second pupa had turned to the per-

manent colour, *viz.*, plum-colour, with a blue bloom on it.

Sept. 4th.—The last three larvæ pupated among leaves on the floor.

Total results of experiment :—

Colour.	No. of larvæ.
Bluish green	... 5
Other colours	... 0
Total ...	... 5

This experiment would have been more satisfactory if I could have had more material to work upon. As I had only two sets of larvæ, I could not satisfy myself as to whether the darkening to brown or remaining green in the second stage was normal. Mr. Poulton experimented with the same species, the results of which are now to be published.

4. *Notes on larvæ of* Mamestra brassicæ.

In June, 1891, some fertile ova of the Cabbage Moth (*M. brassicæ*), from one parent, were sent me by Mr. Poulton, for purposes of experiment in colour-relation.

June 28th.—Thirty larvæ hatched, and were placed together in cylinder 1, and fed on cabbage. The colour of the larvæ was uniform dusky brown ; they had blackish heads.

July 5th. — The first ecdysis occurred; the larvæ having been hatched the same day, moulted together, with a difference of hours only. The larvæ were now light green, with yellowish heads.

July 7th.—I divided the larvæ (now all in the second stage), placing fifteen in cylinder 2, and giving them very dark brown earth as a floor. It was of no use to give black sticks to this species, as they never rest on sticks; so the earth was intended to serve for dark surroundings. Fourteen larvæ were left in cylinder 1 ; one was lost during the operation, and could not be found again. Total, 29.

The larvæ with dark surroundings.

Cylinder 2.—July 13th.—The second ecdysis occurred ; the larvæ changed to a deep green, with lighter longitudinal markings ; heads yellow. Of the fifteen larvæ,

two were somewhat darker green than the rest, and one was very dark olive-green, with a brown head.

July 15th. — The larvæ from this time fed only at certain times, generally about three times a day, and in the intervals of feeding all descended from the leaves, and buried themselves in the earth on the floor of the cylinder.

July 21st.—The third ecdysis took place, and the larvæ all became of varying shades of brownish green, olive-green, and dirty greenish brown; all were fairly dark, but these were darker than the rest. Their heads were also brown, and the longitudinal striping was much darker. The larvæ were large, and getting crowded; so I removed the seven darkest to cylinder 4, giving them dark green leaves and a dark earth floor. Eight larvæ remained in cylinder 2.

July 26th.—The fourth ecdysis occurred. There was no change of colour. The colour had not darkened or altered at all since the change at third ecdysis.

Aug. 12th.—Three larvæ pupated.

Aug. 13th.—The last five larvæ pupated. There was no change of colour due to surroundings in any.

Cylinder 4.—July 21st.—The seven darkest larvæ from cylinder 2 were placed here with dark green leaves and dark earth.

July 26th.—The fourth ecdysis took place. No change of colour either before or afterwards. The larvæ still remained slightly darker than those in cylinder 2, but were otherwise like them.

Aug. 11th.—Four larvæ pupated.

Aug. 12th.—The last three larvæ pupated. No change of colour due to surroundings occurred in any.

The larvæ with green surroundings.

Cylinder 1.—July 7th.—Fourteen larvæ in the second stage were left in cylinder 1, with light green leaves only; no earth was given to these.

July 13th.—The second ecdysis took place. The larvæ changed to a green more or less dark, with slightly lighter longitudinal striping; heads yellow to yellowish brown, as in the larvæ with dark surroundings. From this time the larvæ adopted stated times of feeding, like the others, and in the intervals descended from the

leaves and remained quiescent on the floor. This set had no earth in which to bury, but they constantly covered themselves as much as possible with their excreta, which was brownish green in colour, and always of great quantity; so that it had to be continually cleared out.

July 21st.—The third ecdysis took place, and the larvæ changed to various shades of very dark greenish brown or olive-green; heads brown. Two were very dark. I removed seven of the lightest to cylinder 3, with light green leaves only. Seven were left here.

July 26th.—The fourth ecdysis occurred. No change of colour, which had been quite normal ever since the alteration at third ecdysis.

Aug. 13th.—Five larvæ pupated.

Aug. 14th.—The two last larvæ pupated. No change of colour due to surroundings was perceptible in any of them.

Cylinder 3.—July 21st. — Seven of the lightest larvæ were placed here from cylinder 1, and were given light green leaves and no earth.

July 26th.—The fourth ecdysis took place. The colour had been quite normal since the change at third ecdysis, and no change took place now.

Aug. 12th.—Three larvæ pupated.

Aug. 13th.—The last four larvæ pupated.

Total results of experiment:—

Colour.	No. of larvæ.
Various shades of olive-green to brown ...	29
Other colours	0
Total	29

It will be seen that the above results were entirely negative. The shades of colour are difficult to describe in this species; but all my larvæ, variable as they were in shade, were more brown than green, even when in green surroundings, and this was the case with any larvæ I captured and compared with them. The lack of resemblance to surroundings in this species may be partly due to the burying habit; the greenish brown is sufficiently protective while on the earth, and once buried the colour would be of less importance. Mr. Poulton made some previous experiments with *M. brassicæ*, the results of which are shortly to be published.

Summary of Results.

E. cratægata.

Total number of larvæ experimented with, 19.
Number in dark surroundings, 10.
Number in green surroundings, 9.

The larvæ in dark surroundings.

Very dark brown, approaching to black ...	3
Light brown	3
Intermediate shades of brown	2
Exceptions (green)	2
Total	10

The larvæ in green surroundings.

Brilliant green, with red touches	1
Lighter green	2
Intermediate shades of green	6
Exceptions	0
Total	9

C. nupta.

Total number of larvæ experimented with, 42.
Number in dark surroundings, 12.
Number in green surroundings, 18.
Number in white surroundings, 12.

The larvæ in dark surroundings.

Very dark brown, dark dorsal lines	2
Light brown, faint dorsal lines	3
Intermediate, darkish dorsal lines	7
Total	12

The larvæ in green surroundings.

Light clear brown, light dorsal lines	10
Dark brown, dark dorsal lines	5
Intermediate, darkish dorsal lines	3
Total	18

The larvæ in white surroundings.

Light clear brown, light dorsal lines	5
Dark brown, dark dorsal lines	1
Intermediate, darkish dorsal lines	6
Total	12

C. fraxini.

Total number of larvæ experimented with, 10.
Number in dark surroundings, 5.
Number in green surroundings, 5.

The larvæ in dark surroundings.

Brownish grey or pinkish drab.	5
Exceptions	0
Total	5

The larvæ in green surroundings.

Delicate bluish green	5
Exceptions	0
Total	5

M. brassicæ.

Total number experimented with, 29.
Number in dark surroundings, 15.
Number in green surroundings, 14.

The larvæ in dark surroundings.

Dark brownish green ... ... 15.

The larvæ in green surroundings.

Dark brownish green... ... ... 14.

Section II.

1. *Notes on a possibly protective habit of larvæ of* Rumia cratægata.

In the course of experiments in colour-relation, in June, 1890, I made some observations on a peculiar habit adopted by the young larvæ of *R. cratægata*, which seemed to me possibly significant. Mr. Poulton made numerous observations in previous years on the irregular or spiral attitudes assumed by young Geometer larvæ, mentioning the habit as occurring in *Ephyra pendularia*, *E. omicronaria*, *E. orbicularia*, *Aspilates citraria*, and *A. gilvaria* (Trans. Ent. Soc. Lond., 1884, Part I.), and again in *Selenia lunaria* and *R. cratægata* (Trans. Ent. Soc. Lond., 1887, Part III.). But in my larvæ of the latter species I found this attitude associated with a habit which, so far as I am aware, has not been observed before.

During the third stage the larvæ in cylinders 5 and 9 (*viz.*, those with dark and those with green surroundings),

continually adopted the above-mentioned attitude when at rest, forming themselves into an irregular spiral (Pl. XI., fig. 3), the fore part of the body being bent round so that the head and first five segments were erected almost vertically. This position was retained for hours at a time, either when the larvæ were resting on leaves, or when they were hanging by a supporting thread from the leaf or a stick, which they frequently did, something after the manner described by Mr. Poulton in *E. pendularia* (Trans. Ent. Soc. Lond., 1884, Part I.). The spiral twist was maintained, as well when hanging by the thread as when resting on a leaf; it was most prevalent during the third stage, but some individuals continued it through the fourth and even fifth stages. The spiral attitude was common to both sets of larvæ, green and brown, but was continued much later by the brown larvæ, which also adopted the hanging position much more frequently than the green. In fact, the brown larvæ hung in the spiral attitude almost constantly, and it was when in this position that they adopted the habit I observed. This was that, whenever I examined them, which I did many times every day (without removing the cylinder), the hanging larvæ took to spinning round on their threads with a circular or vibrating motion. I supposed the motion to be accidental, and probably caused by my touching or jogging the cylinders. But I soon noticed that the larvæ spun whenever I examined them, and it seemed to me as if the movement were voluntary, since it occurred when I did not touch the cylinder at all, and when I approached so as not to cause any vibration perceptible to me. The movement appeared circular, but it was so rapid that it might have been vibratory, the rapidity giving a deceptive appearance; the movement caused by jogging or shaking was, however, a to-and-fro one, quite unlike the spinning. The latter motion was not unlike that noticeable in young spiders (*Epeira diademata*), when observed or interfered with in their web; they set the web violently shaking with a round-and-round motion, which confuses the enemy, and renders the spider scarcely distinguishable. The likeness of the brown larvæ, when spinning, to the bits of dead leaves, sticks, or rolled-up spiral leaf-cases one sees hanging on a thread or web in a hedge, and spinning or vibrating in the wind, struck me

at once, and it seemed to me that the likeness might possibly be a protective one. The idea was confirmed by the fact that I found the green larvæ, though adopting the spiral attitude on leaves, hung comparatively seldom, and *never spun at all.* I cannot say positively that the brown larvæ never spun when I did not observe them, but I do not think that they did. At the same time it has been represented to me that it is difficult to conceive how a voluntary motion of the kind can be caused by a larva hanging loose at the end of a thread, and also difficult to see how the larvæ can have become aware of the presence of what they supposed to be an enemy unless by vibration, which did not seem to be the case, or by shadow, which is possible, as I looked very closely at them. I hope to investigate the subject further, and to endeavour to show whether the movement is related to the existence of some disturbance, as, if so, I think it would prove strongly protective.

If the resemblance really is to objects spinning in trees and bushes, the fact that the green larvæ do not spin is exactly what we should expect, for *green* leaves or objects are rarely, if ever, seen in the position described. A green larva would be rendered more easy of detection by the habit, for it would attract the attention of enemies by spinning, and would run some risk of doing so by hanging at all; while on green leaves it is sufficiently protected by its colour. The suggestion is, however, a purely tentative one, and the observation has not much value without further investigation as to the exact nature and causes of the movement.

2. *Notes upon the red spots in* Smerinthus *larvæ.*

On July 30th, 1890, at Mr. Poulton's suggestion, twenty-three newly-hatched larvæ of *Smerinthus tiliæ,* the parents of which had been spotted as larvæ, were sent me by Mr. R. C. L. Perkins, a friend and former pupil of Mr. Poulton. I worked at the ontogeny of these larvæ, with a view to throwing further light, if possible, upon the question of the origin and development of the red spots which sometimes occur in this species.

Since the appearance of Professor Weismann's Essay on 'The Origin of the Markings of Caterpillars,' and Professor R. Meldola's notes on it ('Studies in the Theory

of Descent,' vol. i.), Mr. Poulton made various observations on this species and others of the genus (Trans. Ent. Soc. Lond., 1884, Part. I.; 1885, Part II.; 1886, Part II.; and 1887, Part III.), and his latest conclusion was that the spots in *S. tiliæ* probably arose from a modification of a normal coloured border to the oblique stripes, hence that we have in *S. tiliæ* "a fading away of the character (*i.e.*, coloured borders) instead of its origin."

Unfortunately nineteen of the larvæ sent me by Mr. Perkins were injured in the transit by post, and only four were reared; but all these were spotted. I watched their development very closely, and recorded every change however slight. My observations did not agree in all points with the descriptions of the young larvæ given by Prof. Weismann ('Studies in the Theory of Descent,' vol. i., p. 233). This may have been due to variability in the larvæ; yet certain appearances, either not mentioned by him, or mentioned as occurring at different periods, were found in each of my larvæ; and, as some were transitory, it is possible they may have been overlooked by him, especially as his descriptions are not very detailed.

The following is a record of the appearance of the larvæ day by day:—

July 30th.—I received from Mr. Perkins twenty-three larvæ of *S. tiliæ* just out of the eggs; they were placed in cylinder 15, and fed on elm. Nineteen were injured in transit and were dying or dead. The larvæ were green all over, and the caudal horn was very long and dark violet in colour. No oblique stripes. The dorsal vessel showed through the skin.

Aug. 4th.—Only four larvæ were living; these continued healthy. The first ecdysis of the first larva occurred. It now became light green, with the caudal horn pure green. (This stage is described by Prof. Weismann as occurring *before* first ecdysis, and before the horn becomes violet). The oblique stripes were now faintly discernible, and were green like the ground-colour, only of a more yellowish shade. There was no trace of a subdorsal line as described by Professor Weismann. Length of larva before ecdysis 6 mm. The dorsal vessel still showed through; Prof. Weismann describes this as appearing now for the first time.

Aug. 5th.—The horn of the first larva had acquired a dark rough dotting on the upper surface near the base; the tip and under side were still green. Shagreening appeared.

Aug. 6th.—The horn of the first larva became yellower; the dotting remained the same and became no darker. The length of the larva at this time was 9 mm.

Aug. 9th.—The first ecdysis of the second larva occurred; the horn changed to pure green as in the first larva. Shagreening appeared. The head was brighter green than the rest of the body. No subdorsal line. The horn of the first larva was now reddish at the base, but not darker towards the tip, and the under side of it was quite light and greenish still.

Aug. 11th.—The first ecdysis of the third and fourth larvæ took place; the horn in both changed to pure green as in the others. Shagreening appeared. No subdorsal line. The second ecdysis of the first larva occurred; there was scarcely any change, only the oblique stripes became primrose-yellow and more distinct, and the horn blacker on the upper surface. The apex of the triangular head was very slightly bifid. The length of the larva was $1\frac{1}{2}$ cm.

Aug. 22nd.—The third ecdysis of the first larva took place. A perfect row of nine reddish-yellow spots appeared. Eight were in the position of the spiracles, and one on the supra-anal plate. They were present on the thoracic segments, and the first to eighth abdominal. Spots 1—10 were spiracular in position, and those on the abdominal segments were posterior to the oblique stripes. The spot on abdominal segment eight was the brightest and most distinct, and next in distinctness was that at the base of the horn; towards the head they became less bright, though still distinct. The length of the larva was $2\frac{1}{2}$ cm. The horn was less dark on the upper surface, and there was a very distinct red line on each side of the base; the ground colour was greenish yellow. The oblique stripes were primrose-coloured; they were never at any time white or "whitish" as described by Prof. Weismann, but distinctly pale yellow.

Aug. 24th.—The second ecdysis of the third and fourth larvæ. The change in appearance was exactly the same as in the first and second.

Aug. 25th—Sept. 2nd.—I was absent from home, and

meanwhile the third ecdysis of the second, third, and fourth larvæ occurred. In all three, red spots were found in the spiracular row only, exactly as in the first larva, both as to number and position; the red spot on the supra-anal plate was also present. The change in the horn was also exactly as in the first larva.

Sept. 3rd.—The fourth ecdysis of the first larva occurred. The ground colour was bright yellowish-green; the stripes and shagreen dots pale primrose-yellow. The character of the spiracular spots was slightly changed; whereas in the fourth stage the spiracle itself only showed as an orange-red spot outlined with a deeper green than the body-colour (Pl. XI., fig. 9); each spiracle was now distinctly margined with orange-red, the red area having increased, but being still outlined with deep green (Pl. XI., fig. 10). The most striking change was the development of an upper row of large bold red spots, seven in number, on abdominal segments 1—7, one anterior to each stripe, the second largest being those in front of the third, fourth, and fifth stripes, counting the most anterior stripe as the first. The last spot was the largest, those in front of the first and second stripes much smaller, but distinct; the spot before the sixth stripe was a mere trace. The oblique stripes now took a slight upward bend at the places where the upper spots occurred, and the third, fourth, and fifth stripes were here slightly suffused by the spot, on which the shagreen dots showed up as on a background. The spots showed a slight tendency to lengthen vertically, but kept strictly to the lines of the rings of the body, of which there are eight in each segment. The spots in front of the third, fourth, and fifth stripes covered three rings in width, the last spot four rings, the first and second spots only two rings. The two sides of the larva corresponded exactly. The black dotting of the caudal horn entirely disappeared; immediately after ecdysis the upper surface was pure green, the under surface was yellow, and the red line up the sides was longer and more distinct. The length of the larva was nearly $4\frac{1}{2}$ cm.

Sept. 4th.—The horn of the first larva changed to bluish on the upper surface.

Sept. 5th.—Having been absent on the day the second,

third, and fourth larvæ moulted, I recorded their exact appearance now. In the third larva the spiracular row of spots was faint in colour, but distinct; they were nine in number, on the first thoracic segment and abdominals 1—8, and were orange-red in colour. Those on abdominal segments 1—7 were posterior to each stripe. The shagreen pale yellow dots were placed in vertical lines following the rings of the body. The oblique stripes were primrose-yellow, and the first was the most distinct. I could see no trace of the eighth stripe observed by Mr. Poulton in *Smerinthus* larvæ and *Sphinx ligustri* (Trans. Ent. Soc. Lond., 1886, Part II., and previous papers). The caudal horn was black-dotted on the upper surface, yellow beneath; there were faint traces of the red line extending up the sides from the base. The apex of the head was bifid and faintly red. The thoracic legs were very faintly rosy; there was no red on the claspers. The length of the larva was 3 cm. The fourth larva was exactly as the third. The second larva was evidently nearer the fourth ecdysis; its general ground colour was darker green than that of the others, the stripes and shagreening yellower. The apex of the head was distinctly orange-red and bifid. Only the spiracular row of spots was developed, on the same segments as in the others, but a darkening under the skin was perceptible anterior to the fourth, fifth, and sixth stripes, where the upper row of spots ultimately appears. The caudal horn was black-dotted on a green upper surface, and the red lines from the base upwards were more distinct than in the third and fourth larvæ. The thoracic legs were also redder; there was no red on the claspers. There was no eighth stripe.

Sept. 6th.—The fourth ecdysis of the second and third larvæ took place. The second larva developed an upper row of five spots only; these were in front of the second, third, fourth, fifth, and seventh stripes, *viz.*, on abdominal segments two, three, four, five, and seven. The spots were very small and inconspicuous, also brighter and of a yellower tint than in the first larva, and so narrow in extent as to really appear more like borders than spots at all. Those in front of the second, third, fourth, and fifth stripes occupied three rings each, but were *vertically* a mere line in width, thus giving the border-like appearance. The seventh spot was a mere trace. The two

sides of the larva corresponded. The thoracic legs were faintly red; there was no red on the claspers. The other characters were all as in the first larva. There was no eighth stripe. The third larva developed an upper row of seven spots, one anterior to each stripe, *viz.*, on abdominal segments 1—8. The third and seventh spots occupied four rings, the first two rings, and the rest three rings; nevertheless, the third, fourth, and fifth spots were the largest, because longer vertically than the others. All the spots were larger and more conspicuous than in the second larva, also deeper red. The sides corresponded. All other characters were just as in the first larva.

Sept. 9th.—The fourth ecdysis of the fourth larva took place. It developed an upper row of six spots, one in front of the first, second, third, fourth, fifth, and seventh stripes, *viz.*, on abdominal segments one, two, three, four, five, and seven. The spot in front of the first stripe (on first abdominal segment) was the smallest, occupying two rings; the others each occupied three rings. Other characters as in the first larva.

Sept. 10th.—The upper row of spots in the first larva increased in width; the third, fourth, and fifth spots (on abdominal segments one, two, and three) now covered four rings. This increase in the width of spots did not happen in any other larvæ.

Sept. 25th.—The first larva pupated.

Sept. 27th.—The second, third, and fourth larvæ pupated. The larva figured (Pl. XI., fig. 8) is the first.

Smerinthus populi.

On August 8th, 1890, I captured a red-spotted larva of *S. populi* in the fourth stage on poplar.

Aug 12th.—I drew (Pl. XI., fig. 11) abdominal segments five and six to show the spots. There were two rows of spots, of ten each, the upper row being the largest. The upper row were placed one anterior to each oblique stripe, and four extra to these placed irregularly towards the head. The lower (spiracular) row were placed one posterior to each stripe, two extra on the last segment, and one extra towards the head. The spots in both rows were irregular and roundish.

Aug. 19th.—A change took place in the spiracular spots without any moult. The lower row became like

eyes, of which the pupil was yellowish red, *viz.*, the spiracle itself; the iris green, boldly outlined with red (Pl. XI., fig. 12).

Aug. 22nd.—The fourth ecdysis occurred. Both rows of spots slightly increased in size, lengthening vertically so as almost to connect stripe with stripe, but not increasing horizontally. The appearance was not in the least border-like.

Sept. 5th.—The spiracular row of spots was now eleven, another having appeared; there was a spot on each of thoracic segments two and three, the one on thoracic segment three being a mere trace. (On these segments there were no spots in *S. tiliæ*). The spots were still more eye-like, being more broadly margined with red. The upper row of spots now numbered eleven also, the extra spot occurring on the last segment, vertically above the last of the lower row. The last spot but one occupied five rings (two in the penultinate segment, and three in the last); this was the only one which invaded another segment. The first, second, third, fourth, and fifth spots occupied four rings, and the eleventh, first, second, third, and fourth only three rings. But the tenth, eighth, seventh, and sixth were the largest, owing to vertical extension, and these slightly suffused the stripes. Both sides corresponded. The head was suffused with red. The thoracic legs were red, and there was a red spot on each of the claspers. The ground colour of the caudal horn was yellow, the base was blackish above and reddish beneath, and a red line ran up from in front of the seventh stripe to the base, connecting it with the tenth spot. This line was the only attempt at extension borderwise, for the widening on August 22nd was accompanied by great vertical extension, which quite prevented a border-like appearance. The larva ceased feeding on Sept. 8th, and pupated during the night of Sept. 14th. The spots in *S. populi* were unlike those in *S. tiliæ* in general effect, being rounder, bolder, and not in the least linear, and I noticed, as had been previously done by other observers (notably Mr. Peter Cameron, as stated by Prof. Meldola in his notes to Prof. Weismann's 'Essay on the Markings of Caterpillars'), that they were strongly protective, from their resemblance to the dark spots or blotches commonly seen on the leaves of the poplar. Viewed from under-

neath, with the light shining through them, the leaf-spots were of a red exactly corresponding to that of the larva-spots, and much the same size. I did not, however, see the likeness to *galls* (*Phytoptus*) suggested by Mr. Cameron (Trans. Ent. Soc. 1880, p. 69), for the effect produced by a flat spot and a raised object such as a gall would, I think, be very different. But my larva was quite difficult to find, even on a small twig, when viewed from below, and it would have been admirably concealed from enemies below it at any rate.

In *S. tiliæ* I could see nothing in the spots which would have led me to connect them with coloured borders until the second larva reached its last stage, but the appearance of the spots in this individual was so linear and so unmistakeably border-like, that it seemed impossible to doubt the correspondence.

It would have been natural to conclude, from appearances, that the spots are merely protective in *S. populi*, and in *S. tiliæ* have either degenerated from coloured borders, or are on the way to become such; but that it seems unlikely that the character can have a different significance in the two species. It seems to me more probable that spot-marking is the most ancestral, as Prof. Weismann originally suggested, and that *S. tiliæ* represents a stage of its modification into stripes. The fact that the spots do increase in area in both species, though in two directions, seems to point to the character being a developing one. If we had to do with a gradual shortening of borders contracting into spot-markings, it seems more likely that if any change in area of the spots took place it would be in the direction of contraction, which was never the case in my larvæ. There seemed to be no vestige of a former extension along the stripe; even when a stripe was suffused with red, it was so vertically downwards, and never partially affected an extra ring so as to lead one to suppose the spot had once been broader. But the number of larvæ reared was too limited to draw conclusions from safely, and it is possible that if I had had more individuals under observation, some of them might have presented different appearances.

4. *Experiments as to the palatability of conspicuous larvæ.*

In May and June, 1890, I made experiments with larvæ of *Diloba cæruleocephala* and *Cucullia verbasci* on a

tame jackdaw. The bird in question had been taken unfledged in June of the previous year, and reared in captivity. He had never seen larvæ, except those I gave him, unless some might occasionally drop from a beech tree, the boughs of which overhung his cage in the garden.

May 30th. — I took some larvæ of *D. cæruleocephala*, feeding freely exposed on pear trees; they were blue, yellow, and black, not hairy, very conspicuous. One was given to the jackdaw, which had been fed early in the morning (this was midday), and so was not very hungry. The bird looked at the larva suspiciously for a long time, and would not take it. Then he seized it, and, on tasting it, shook his head violently, evidently disliking it. He then dropped it, but picked it up and tried it again, shook his head as before, and finally put it down on the floor of the cage and refused to eat it.

May 31st.—I tried the jackdaw with a common smooth green larva (species unknown); he ate it at once with avidity.

June 20th. — I took two larvæ of *Cucullia verbasci*, feeding together exposed on upper side of leaves of mullein; they were green, yellow, and black, very conspicuous, not hairy.

June 21st.—The jackdaw was purposely not fed, and by the middle of the day he was very hungry, for he carried his empty food-vessel and stood it up against the bars of the cage, an invariable habit when really hungry. The largest larva was offered to him. At first he refused it, then took it, but dropped it instantly, shaking his head, and never touched it again. He appeared quite subdued for a time, and sat shaking his head and swallowing. Nor would he take anything else offered him at all for a little while, but finally ate a gooseberry with relish.

The unpleasant attribute in both species seemed to be taste. Mr. Poulton mentions (Proc. Zool. Soc. Lond., March 1st, 1887) Mr. J. Jenner Weir having experimented with *D. cæruleocephala*, "using many species of birds and lizards," and says the larvæ were "disregarded by all the birds," or "examined when moving, but not eaten." This, he says, gave "strong support" to Prof. Wallace's suggestion, "that brilliant and conspicuous larvæ would be refused by some at least of their enemies,"

while it afforded "no evidence" for Mr. Poulton's suggestion "that a limit to the success of this method of defence would result from the hunger which the success itself tends to produce."

My experiment affords strong support to Mr. Poulton's suggestion, since the larva was tasted twice, and that when the bird was not especially hungry, which points to its being eaten if he had been excessively hungry.

Mr. Poulton says that Mr. Jenner Weir also experimented with *Cucullia verbasci*, on "many species of birds and lizards," and that the larvæ were "disregarded." He refers to this as "strong support" to Prof. Wallace's suggestion, and as "no evidence" for his own.

My experiment afforded some support to Mr. Poulton's suggestion, since the larva was tasted once, and tasting would put a limit to the success of the method of defence as well as eating, because it would be fatal to the larva. I do not think, however, that this species would have been eaten in any degree of hunger.

Both my experiments supported Prof. Wallace's suggestion also, as the larvæ were in both cases refused at first; and, if the bird had not been very hungry, I do not think he would even have tasted *C. verbasci*.

In September, 1892, I also made some experiments with larvæ of *Acronycta psi* and *Bombyx rubi* on three slowworms (*A. fragilis*), and one lizard (*Z. vivipara*). Both species were entirely disregarded by all the animals, though they were kept very hungry, and the larvæ left with them for days.

It may not be out of place to note here that during this experiment I had incontestable evidence of the nature of the food taken by *A. fragilis* in the natural state. The slowworms received rather rough handling when captured, and immediately afterwards cast up a quantity of half-digested food, among which I found a perfectly uninjured adult shell of *Zonites radiatulus*. Remains of slugs were also recognizable. It is rather remarkable that *A. fragilis* should be able to swallow so large and hard an object as the snail-shell.

Explanation of Plate XI.

Fig. 1.—Green larva of *R. cratægata*, last stage, nat. size.

Fig. 2.—Brown larva of *R. cratægata*, last stage, nat. size, resting on black stick.

Fig. 3.—Larva of *R. cratægata* (brown form), in spiral attitude, resting on stick, × 4 diameters.

Fig. 4.—Larva of *C. nupta* (dark surroundings), nat. size, fifth stage.

Fig. 5.—Larva of *C. nupta* (green surroundings), nat. size, fifth stage. (The first abdominal segment has been inadvertently omitted).

Fig. 6.—Larva of *C. fraxini* (dark surroundings), nat. size, last stage, resting on black stick.

Fig. 7.—Larva of *C. fraxini* (green surroundings), nat. size, last stage. (This larva was only placed on a stick for convenience of drawing).

Fig. 8.—Larva of *S. tiliæ*, nat. size, last stage.

Fig. 9.—Fifth and sixth abdominal segments of larva of *S. tiliæ*, fourth stage, immediately after ecdysis, showing first appearance of spiracular spots, × 4 diameters.

Fig. 10.—Fourth and fifth abdominal segments of larva of *S. tiliæ*, fifth stage, showing first appearance of upper row of spots, × 4 diameters.

Fig. 11.—Fifth and sixth abdominal segments of larva of *S. populi*, fourth stage, × 4 diameters.

Fig. 12.—Fifth and sixth abdominal segments of larva of *S. populi*, fourth stage, shortly before last ecdysis, × 4 diameters.

Fig. 13.—Same segments, fifth stage, after last ecdysis, × 4 diameters.